A Brief History of UWB Communications

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The origin of ultra wideband (UWB) technology stems from work in time-domain electromagnetics begun in 1962 to fully describe the transient behavior of a certain class of microwave networks through their characteristic impulse response (Ross 1963, 1966). The concept was indeed quite simple. Instead of characterizing a linear, time-invariant (LTI) system by the more conventional means of a swept frequency response (i.e., amplitude and phase measurements versus frequency), an LTI system could alternatively be fully characterized by its response to an impulsive excitation -- the so-called *impulse response* h(t). In particular, the output y(t) of such a system to any arbitrary input x(t) could be uniquely determined by the well-known convolution integral (e.g., Papoulis 1962):

$$y(t) = \int_{-\infty}^{\infty} h(u)\, x(t-u)\, du$$

However, it was not until the advent of the sampling oscilloscope (Hewlett-Packard c.1962) and the development of techniques for subnanosecond (baseband) pulse generation, to provide suitable approximations to an impulse excitation, that the impulse response of microwave networks could be directly observed and measured.

Once impulse measurement techniques were applied to the design of wideband, radiating antenna elements (Ross 1968), it quickly became obvious that short pulse radar and communications systems could be developed with the same set of tools. While at the Sperry Research Center, then part of the Sperry Rand Corporation, Ross applied these techniques to various applications in radar and communications (Bennett & Ross 1978). This article is highly recommended reading for those interested in past and present applications of UWB technology. (A copy of the Bennett and Ross paper can be found here.)

The invention of a sensitive, short pulse receiver (Robbins 1972) to replace the cumbersome time-domain sampling oscilloscope further accelerated system development. In 1973, Sperry was awarded the first UWB communications patent (Ross 1973). A copy of this fundamental UWB patent can be downloaded here:


Transmission and Reception System for Generating and Receiving Base-band Duration Pulse Signals without Distortion for Short Base-band Pulse Communication System
U.S. Patent No. 3,728,632 dated 17 April 1973 (1.72Mb)

Through the late 1980's, this technology was alternately referred to as *baseband*, *carrier-free* or *impulse* – the term "ultra wideband" not being applied until approximately 1989

by the U.S. Department of Defense. By that time, UWB theory, techniques and many hardware approaches had experienced nearly 30 years of extensive development. By 1989, for example, Sperry had been awarded over 50 patents in the field covering UWB pulse generation and reception methods, and applications such as communications, radar, automobile collision avoidance, positioning systems, liquid level sensing and altimetry.

In 1984, recognizing the value of UWB technology in the development of low probability of intercept and detection (LPI/D) communications systems, Dr. Ross prepared a seminal paper entitled "Comments on Baseband or Carrier-Free Communications". Collaborating with Dr. Robert Fontana, currently MSSI President, Ross and Fontana designed, developed and implemented an LPI/D communications system, funded by the U.S. Government in 1986 and fielded in September 1987. Drs. Fontana and Ross continued collaboration on UWB system development for both communications and radar applications for approximately 11 years.

Within the United States, much of the early work in the UWB field (prior to 1994), particularly in the area of impulse communications, was performed under classified U.S. Government programs. Since 1994, however, much of the work has been carried out without classification restrictions, and the development of UWB technology has greatly accelerated. See, for example, a recent compendium of UWB applications in:


Recent Applications of Ultra Wideband Radar and Communications Systems **(paper) -- Ultra-Wideband, Short-Pulse Electromagnetics**, KLUWER ACADEMIC/PLENUM PUBLISHERS, 2000 (676 kB)

References

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Papoulis, A., 1962, The Fourier Integral and Its Applications, McGraw-Hill, New York, Chapter 5.

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Ross, G.F., 1973, Transmission and reception system for generating and receiving base-band duration pulse signals for short base-band pulse communication system, U.S. Patent 3,728,632.

Ross, G.F., 1968, A time domain criterion for the design of wideband radiating elements, IEEE Trans. Antennas Propagat., Vol. 16, No. 3, p. 355.

For an excellent compendium of patents, papers, essential book references and bibliography on ultra wideband technology, please see Æther Wire & Location, Inc.'s CD-ROM collection at

http://www.aetherwire.com/CDROM/Welcome.html.

An extensive bibliography on UWB technology can be found in the U.S. Patent and Trademark Office *Reexamination Certificate* which upholds the patentability of Thomas McEwan's *Ultra-Wideband Radar Motion Sensor* (U.S. Patent No. 5,361,070, dated 1 November 1994). A copy can be downloaded here:

Reexamination Certificate, U.S. Patent No. 5,361,070 (Thomas McEwan)
(745,472 bytes)